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an area of about 2,000 square miles between Fargo and Grand Forks.

In the western United States more extensive areas were controlled by primary triangulation. In Montana a belt of triangulation was extended down the Milk River for over 100 miles from Fort Assinniboine. In Wyoming a belt was extended across the State from north to south between the neighbourhoods of Laramie and Buffalo; in eastern Washington, from North Yakima through Yakima, Douglas, and Kittitas Counties to the international boundary. In eastern and central Oregon large areas were similarly controlled in Grant, Harney, and Malheur Counties, and in the famous Modoc lava-beds country. In Arizona a belt of triangulation was extended from the neighbourhood of Florence, *via* Tucson, to the Mexican boundary near Nogales.

Throughout the various regions in which topographic mapping was in progress there were run about 17,000 miles of very accurate primary levels, and 25,000 linear miles of secondary levels of less accuracy, for the location of contour lines upon the topographic maps. Some precise levelling was extended near the Pacific coast in the upper Sacramento valley, with a view to reducing the spirit-levelling to mean sea-level datum. In connection with all this spirit-levelling many thousands of bench-marks were established, which will serve as reference points for engineers and others who may have to make use of careful levels in connection with their work.

H. M. W.

THE PANAMA CANAL IN ITS COMMERCIAL ASPECTS.

BY

EMORY R. JOHNSON.

As the beginning of the actual work of constructing an Isthmian canal seems to be close at hand, the present is an opportune time for making a careful study of the commercial aspects of the great waterway. The purpose of the present paper is to consider the effects which the canal will have on commercial routes and the volume of traffic that will make use of the waterway at the commencement and during the early years of its operation.

The use that will be made of the canal will depend upon the

economies resulting from the opening of the new route. The saving that will be possible consists to a small extent of a reduction in insurance charges. A considerable share of the traffic that will be diverted to the new route now passes through the Straits of Magellan by steamers, or around Cape Horn in sailing vessels. Just how great a reduction in insurance costs will take place is impossible to predict, but estimates of a saving of 25% to 50% have been made by those engaged in insurance business.

The greater efficiency which shipping will possess because of the shorter and more expeditious route will be an advantage the amount of which cannot be fully measured by the economies resulting from lower insurance charges or by the shortening of distances, to which reference will presently be made. To a considerable extent ships are operated as a part of business enterprises, and the fact that a vessel can make more trips and handle more tonnage in a year not only reduces the amount of capital that must necessarily be invested by a business concern, but also enables the business in question to be carried on under more favourable circumstances. When there is a large surplus of vessels seeking employment this advantage is not important; but when there is a scarcity of shipping, as not infrequently occurs, the ability to make voyages quickly and to handle a large amount of traffic with a relatively small tonnage of vessels is of much importance.

The most important saving effected by the canal will result in the shortening of distances. This economy, however, will be in part offset (1) by the delay incidental to passing through the canal, (2) by the tolls charged for using the waterway.

The time required for making the transit from the Caribbean Sea to the Bay of Panama by way of the Panama Canal will average about 12 hours. Small ships can make the trip in less time; while the largest vessels will take somewhat more than twelve hours for the trip between Colon and Panama. Any vessel arriving at either terminus early in the morning can make the passage through the canal during daylight of the day of arrival. A vessel arriving in the evening or during the night can also proceed on its trip through the canal, provided the canal is thoroughly lighted, as it presumably will be. It is probable, however, that vessels of the largest size will prefer to wait a few hours in order to make the passage by daylight. On the average, a vessel will be detained somewhat less than a day, including the passage through the canal.

The question of tolls and their influence on traffic can best be considered in connection with a discussion of distances. A care-

ful study of the effect of tolls upon the traffic of the American waterway indicates very clearly that the charges must be placed much lower than the Suez tolls. The charges at Suez are 8.50 francs per ton net register, Danube measurement; but as this measurement makes the net registry of vessels average about 20% more than when measured according to British or American rules, the charge for using the Suez Canal amounts to about \$2 per ton net register, according to our methods of determining tonnage. For some of the traffic available for the American canal such a charge would be prohibitive.

The saving in distances that will result from the opening of the Panama Canal was fully set forth in the BULLETIN of last April. The facts there presented make possible the determination of the territorial limits within which the Panama Canal will be able to draw its traffic, and enable a statement to be made of the amount of tonnage which the commerce within those limits may be expected to send through the waterway. The effect of the canal upon the diversion of traffic may be indicated by considering the subject under six heads:

1. The commerce of the western seaboard of the United States—including Hawaii—with the Gulf and Atlantic ports of the United States and with Europe may be considered as certain to use the new canal route. The shortening of the distance will be so great as to leave no doubt of the diversion of traffic from existing lines to the new route even were the tolls placed as high as those charged at Suez.

2. The commerce of Western South America with the Gulf and Atlantic sections of the United States will also be entirely diverted through the Panama Canal. The distance from New York through the canal to a port as far south as Valparaiso will be 3,850 miles, or 45%, less by way of Panama than *via* the Straits of Magellan; and between the ports of our coasts south of New York and the cities on the west side of South America north of Valparaiso the absolute and percentage reduction in distance will be much greater. Here, likewise, a toll of as much as \$2 per ton might be charged without keeping the traffic away from the new route.

3. The commerce between the eastern seaboard of the United States and the Asiatic ports north of Hong Kong will be practically certain to make use of the Panama route, provided the tolls are not made exorbitant. The distance to Shanghai *via* Panama will be 2,000 miles less than by Suez. From New York to Yokohama the new route will save 4,000 miles.

4. The effect of the Panama Canal upon the traffic between Europe and Western South America merits especially careful consideration in connection with the effects of tolls. The influence of the proposed route upon commerce can be measured to advantage by referring to the nitrate of soda exports from Northern Chile. Three-fourths of the Chilean export tonnage consists of nitrate, the deposits of which are located in the middle part of the western coast of South America. The average distance from the ports of Northern Europe—Antwerp, Hamburg, Liverpool—to the nitrate deposits will be shortened about 2,800 nautical miles. The present distance by way of the Straits of Magellan will be reduced about 30%. A saving of this distance would shorten the time of the voyage for a 10-knot steamer 11 days 16 hours. As the passage through the canal will detain the vessels somewhat less than a day, it may be said that the Panama Canal will reduce the trip for steamers between Europe and the nitrate beds about 11 days. A vessel operated at a speed of 9 knots an hour (which is the present speed of a large share of the tramp steamers) would shorten the time of the voyage nearly 13 days. Careful calculations of the net economy resulting from a reduction of 11 to 13 days in the time of making voyages between Europe and the central ports of South America indicate that it would be profitable for steamers to abandon the present route by the Straits of Magellan in favour of the Panama route. At the present time the largest part of the nitrate is carried in sailing vessels whose route is around Cape Horn. It is, however, not probable that a very large percentage of this traffic can be economically handled by sailing vessels by this circuitous route after the canal becomes available for steamers, provided a toll of not more than \$1 per ton net register is charged for the use of the canal. A higher charge than this would doubtless cause many steamers to hold to the present Straits of Magellan route, and sailing vessels to continue to compete indefinitely with steamers for this bulky traffic.

5. The commerce between the eastern seaboard of the United States and Australia now goes around the Cape of Good Hope. The distance by the Suez and Cape routes is practically the same; consequently, when the American canal is opened the competition for the New York—Australia trade will be between the Isthmian Canal and the Cape of Good Hope routes. The distance from New York to Sydney *via* the Panama Canal and Tahiti will be 9,852 nautical miles; by the Cape of Good Hope, Adelaide, and Melbourne the distance to Sydney is 13,658 miles, the distance in

favour of the American isthmus being 3,806 miles. A 10-knot vessel would save about 15 days by taking the American canal route, and certainly would prefer that passage if tolls did not exceed \$1 per ton net register. Practically, all vessels going to Australia, whether from Europe or the United States, call at Sydney because it is the most important port, and because coal can be obtained there or near by. For the trip from New York to Melbourne the Panama route would save about 11 days, and a toll of \$1 could profitably be paid to accomplish this. There is, then, no doubt that steamers outbound from the Eastern section of the United States to Australia will prefer the American canal route with a toll of \$1. The course taken by the vessels on their return will naturally be determined by the destination of the Australian exports. The ships that secure a whole cargo for America will return by the American canal. Likewise, those vessels that secure a partial cargo for the United States and a partial cargo for Europe will return by the Panama Canal. Steamers securing a full cargo for Europe in Australian ports will probably return by the Cape of Good Hope, although cheaper coal in American stations might cause the American canal to be used. The distance from Sydney to Liverpool by way of the American canal is only about 200 miles longer than the route by way of Melbourne, Adelaide, King George's Sound, Colombo, Adelaide, and the Suez Canal.

6. The effect of the Panama Canal upon the routes followed by the trade of our eastern seaboard with the Philippines will depend very largely upon the amount of tolls charged. Low tolls will divert a considerable share of the traffic from the Suez route to the one across the Isthmus of Panama. The distances from New York to Manila by the two canals are practically the same. From our South Atlantic and Gulf ports the distance to Manila is considerably less by the Panama route. Chartered vessels outbound from New York will doubtless go sometimes by one route and sometimes by the other. The chief attraction of the American route will be the coasting trade of both seaboard of the United States, the shortest route from the American isthmus to Manila being by way of the great circle which passes close to San Francisco. It will accordingly be possible for vessels sailing under the American flag to follow the course of the heaviest traffic movements—*i. e.*, to load with heavy manufactures or with other cargoes from the Atlantic or Gulf ports for the western ports of the United States; thence to take American grain and other food-products and manufactures to the Orient and the Philippines, and to load back for the United

States with hemp or other cargoes from the East. The coal obtainable in the Caribbean and Japanese stations will be inexpensive, and the American canal will have special facilities for competing with the Suez Canal, particularly if the American canal tolls are made less, as they unquestionably will be, than those charged by the Suez Canal Company. The Philippine Islands are so nearly antipodal to the eastern seaboard of the United States that the route taken by the commerce between the two sections will be determined almost entirely by the relative rates of tolls prevailing at the two waterways.

In view of the fact that the largest part of the Suez traffic can afford to pay a high toll rather than abandon that route, it is not probable that the Suez Canal Company will find it profitable to make a radical reduction in its charges—50%, for instance—in order to hold the commerce of the regions situated on the margin of advantage as regards the use of the eastern or western canal routes. Consequently, it would seem that the adoption of moderate tolls—not to exceed \$1 per ton net register, American measurement—for the use of the American canal will enable that waterway to secure a large share of the commerce carried on between sections so situated that their trade with each other can choose between the Suez and American routes.

In general, it may be said that there is but little of the available Panama Canal traffic that would be kept from using the waterway by a toll of \$1 per ton net register. The European trade with Western South America and the commerce of our eastern seaboard with Australia and Asia north of Hong Kong will not be driven from our canal by a toll of that amount, but it seems probable that a higher charge than \$1 a net register ton would considerably restrict the other categories of traffic discussed in the foregoing paragraphs. A toll that largely restricted the traffic of the canal would limit the industrial and commercial value of the new route and deprive our country of many benefits it would otherwise secure. A toll of \$1 a vessel ton net register would yield an income sufficient to pay the expenses of operation and maintenance and a moderate return on the capital invested, as the following statement of tonnage will show. Should the United States prefer to levy tolls sufficient only to cover the costs of operation and maintenance a tariff of 40 cents or 50 cents a ton will undoubtedly be sufficient.

THE TONNAGE OF CANAL TRAFFIC.

In 1900 and 1901 the writer, while serving as a member of the Isthmian Canal Commission, made a detailed investigation to deter-

mine the traffic available for the canal during the year 1899, the latest year for which statistical material was available. Two investigations were made—one to determine the tonnage of freight or cargoes that would have used the canal during 1899, and the other to ascertain the net register tonnage of vessels that would have passed the canal during that year.

In the study of *cargo* tonnage special difficulties were encountered, because the available statistics compiled and published by the United States and other Governments do not give the weight of commodities exported and imported. In the case of our own statistics values are given for each of 328 classes of exports and 333 classes of imports. In some instances quantities as well as values are stated; but the weight corresponding either with values or quantities had to be determined by correspondence with exporters and importers in different parts of the United States. The conversion of the figures for values and quantities into their accurate equivalents in weight or tonnage was a laborious undertaking, which, however, was carried through with great thoroughness and detail.

It was found that the traffic of the two seaboard of the United States with each other and with the sections of the world with which our commerce would have unquestionably been carried on through a canal, had there been one in existence, amounted to 3,435,887 cargo tons in 1889. The value of this traffic was \$127,716,000. The commerce of Europe with the western coast of Central and South America, with Hawaii and British Columbia, in 1899, comprised 3,266,654 cargo tons. The sum of these two totals is 6,702,541 tons. These figures do not comprise any commerce between Europe and the western coast of Mexico; nor do they include any of the trade between Europe and Eastern countries, a part of which would, for reasons stated above, have passed through the American canal. It will be understood, moreover, that the figures apply to the commerce of the past carried on under conditions then prevailing. They do not refer to the commerce of the future, which, when the canal is opened, will be carried on under very different circumstances.

The tonnage of the *vessels* that would have used a canal in 1899 was ascertained by a study of the statistics of entrances and clearances compiled by the United States and European countries. Unexpected difficulties were encountered in this inquiry, arising from the fact that different countries follow different rules in the compilation of entrance and clearance statistics, and also because it

was necessary to be on one's guard against duplication. Great care was taken to avoid this, and to make certain that the statistics should err, if at all, on the side of under-statement rather than of exaggeration.

The following table summarizes the vessel tonnage which the commerce of America and of Europe with America might have contributed to a canal in 1899:

SUMMARY OF ENTRANCES AND CLEARANCES, COMMERCE OF EUROPE WITH PACIFIC AMERICA, AND COMMERCE OF EASTERN SEABOARD OF THE UNITED STATES WITH PACIFIC COUNTRIES, 1899.

Europe with

Western South America.....	1,771,853
Western Central America and Mexico.....	140,000
Pacific Coast of United States, British Columbia, and Hawaii.....	642,180

Eastern Seaboard of United States with

Western South America and Hawaii.....	166,364
Pacific Coast of the United States.....	109,312
Trans-Pacific Countries.....	908,140
Panama Traffic (1898).....	336,998
Total.....	4,074,852

In addition to this tonnage, which comprises only traffic originating or terminating in America, there should be included most of the commerce of Europe with New Zealand and the other islands of the Pacific east of Australia. New Zealand will be about 1,500 miles nearer Liverpool by the Panama Canal than *via* the Suez route, and about 2,400 miles nearer than by way of the Cape of Good Hope. The distances to Liverpool from the most important groups of South Pacific Islands north of New Zealand will be from 500 to 5,000 miles less *via* the Isthmian Canal than by way of Suez. The entrances and clearances of New Zealand's trade with northwestern Europe, France, and countries farther north amounted to 481,178 tons net register in 1899, and the commerce of that part of Europe with the other islands of the South Pacific east of Australia to 181,743 tons. Of this total traffic of 662,921 tons not less than 500,000 might have advantageously used an Isthmian canal, and this amount should be added to the tonnage of the canal traffic originating or terminating in America. This makes the total obtained by the Commission's investigation of the tonnage that

might have used an Isthmian canal, in 1899, 4,574,852 tons net register.

The above totals for the tonnage that might have used an Isthmian canal in 1899 do not include any of Europe's trade with Australia and Japan, a part of which would have used an Isthmian waterway. The distance from Great Britain to Sydney and Yokohama by the Suez and Isthmian Canal routes is approximately the same, and vessels going by America in either direction *en route* between Europe and Japan or Australia will pass regions from which there is a heavy export tonnage. If it be assumed that only 10 per cent. of the vessel tonnage of the Australian trade with the ports of northwestern Europe and only 5 per cent. of the tonnage of the Japanese commerce with those ports would have taken an American canal route the total for 1899 should be increased 316,223 tons, and be raised from 4,574,852 to 4,891,075 tons.

It was, fortunately, possible to compare the results of the two investigations made for the Canal Commission with the figures for canal traffic that had been determined by the New Panama Canal Company as the result of an elaborate study of vessel movements which that company had carried on continuously from the beginning of 1894. The method employed by the New Panama Canal Company was to make a list of all the vessels of the world, to keep a record of their movements, and at the close of each year to summarize the tonnage of those vessels whose movements had been such that they would have passed through the Panama Canal had there been one in existence. This elaborate and excellent study showed that a total traffic of 5,001,798 tons net register would have passed through the canal during 1899. The figures obtained by the New Panama Canal Company were slightly in excess of those resulting from the investigation made for the Commission by a study of entrances and clearances; but the two totals corresponded as nearly as could have been expected, in view of the differences of the methods employed, and in view of the fact that the two periods covered were not exactly synchronous. In each case the total approximated 5,000,000 tons.

The prospect is that the canal will be completed and ready for traffic by 1914. To what figures will the available tonnage of 1899 have increased during the fifteen years ending in 1914? In order to show more clearly the rate at which the tonnage of available traffic was increasing the New Panama Canal Company in 1898 computed the tonnage of traffic that was available in 1888. A study of their figures for those two years shows that the available

canal traffic had increased 25.1 per cent. during that decade. In order to determine whether that rate of increase might properly be accepted, the writer made a study of the rate of growth of traffic of various sections of the world with the United States and Europe.

It was found that the value of the trade between the Atlantic coast of the United States and Pacific South America increased 26.8 per cent. during the decade 1889-1899. For the commerce between our Atlantic seaboard and Pacific countries other than South America the growth was 49.7 per cent. The trade of the United States with Australasia more than doubled during the decade ending in 1900. The vessel movements between Europe and Chile increased 33.3 per cent. during the ten years ending in 1898. European entrances from the west coast of South America gained 36.5 per cent. While the trade between the Pacific Coast of the United States and trans-Pacific countries will not use the canal, the rate at which that commerce is increasing may well be considered in this connection. The total entrances and clearances of the trade between our Pacific Coast and Hawaii, Siberia, Japan, China, and Hong Kong gained 191 per cent. from 1889 to 1899.

It was evident that a rate of 25.1 per cent. per decade might be taken as a very conservative estimate of the growth in the tonnage of available canal traffic between 1899 and 1914. An increase of 25.1 per cent. per decade would raise the tonnage of 1899 to approximately 7,000,000 tons for 1914; and a traffic of that amount may safely be predicted for the early years of the operation of the canal.

The rate at which the traffic of the canal will increase after the waterway has been put in operation must be a matter of conjecture. But it will be interesting to inquire what the prospects are. One naturally turns to the Suez Canal for the purpose of comparison; but the history of the traffic of that waterway can hardly be repeated in the case of the Panama Canal route. The Suez Canal was opened in 1869, and there was a very moderate growth of traffic for about five years. The total net tonnage for the first five years amounted to only 5,358,237 vessel tons. The slow increase during the first few years was due to the fact that the Suez Canal could be used only by steamers, and in 1870 there was but a small number of steamers available for the commerce of Europe with the East Indies. Steamers had to be constructed and substituted for sailing vessels before the Suez route could be adopted in place of the course around the Cape of Good Hope for any considerable volume of traffic. After the substitution had

been made the rate of increase in tonnage was rapid. During the third five-year period the traffic was 217 per cent. of that of the second five-year period. During the fourth five-year period the traffic was 286 per cent. of that of the second five-year period, and during the sixth quinquennial period—1895–1899—the tonnage was 401 per cent. of the traffic during the years 1875–1879. During the last quinquennial period of the twenty-five years from 1875 to 1899 the traffic of the Suez Canal was four times that of the first five years of that period. During the second decade of the operation of the Suez Canal—that is, from 1880 to 1890—there was an increase of 125 per cent. tonnage over the previous decade.

If it be assumed that the tonnage of the American canal during the first ten years of its operation will increase only one-half as fast as the traffic of the Suez Canal did during the second decade of its existence, the rate of growth predicted for the Panama Canal will be $62\frac{1}{2}$ per cent. An increase of $62\frac{1}{2}$ per cent. in the estimated figures for 1914—approximately, 7,000,000 tons—would give a tonnage of about 11,250,000 for the year 1954. It would be difficult to conceive of a more conservative estimate than this, and yet it shows a relatively large prospective traffic for the American canal at the the close of the first ten years. The figures for the American canal for 1924 are about the same as those for the present tonnage of the Suez Canal. The traffic of the Suez waterway in 1914 will probably be at least one and one-half times its present amount.

THE EXPLORATIONS OF THE RUSSIAN HYDROGRAPHIC EXPEDITION IN THE ARCTIC OCEAN IN 1902.*

The Russian Hydrographic Commission reports, concerning the fifth season of field work in the Arctic Ocean during the summer of 1902, that important progress was made in the survey of the coast-line and in the sounding and survey of the Kara Sea and of the shoals on the White Sea. Much material was obtained for the correction of the very imperfect existing charts of the region. During the frequent interruptions of survey work, on account of the ice, meteorologic, magnetic, tidal, and current observations were made, and dredging was done for the collection of material

* Condensed from *Annalen d. Hydr. u. Marit. Meteorologie*, 1903, Heft XI, p. 492.